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ABSTRACT

In order to prepare an up-to-date instruments course and provide data on which to publish a text for an associate degree electronics curriculum, the investigator of this study (a competency analysis) surveyed twenty-four Wisconsin- and Minnesota-based firms to identify job entry skills expected of electronics technicians. Of the firms surveyed, twenty-two employer/supervisors and twenty-one technicians ranked instruments, competencies, and general electronics concepts. Their combined opinions showed that five instruments (digital voltmeter, analogue voltmeter, oscilloscope with triggered sweep, D.C. power supply, and recorders/printers) should form the core of an instrument course. Concepts relating to grounding and accuracy were also considered to be a part of the basic groundwork. From this competency analysis an instrument course was identified. Two of the five conclusions presented were that it was possible to identify instruments and competency priorities by using a competency analysis and that the process of competency analysis provides instructors with information on which to build or revise an instrument course. (Data collection instruments are included in the appendix.) (JH)

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AN ANALYSIS TO DETERMINE COMPETENCIES WITH ELECTRONIC INSTRUMENTS FOR AN ASSOCIATE DEGREE PROGRAM IN THE WISCONSIN VTAE SYSTEM

by

Eugene V. Solberg

June, 1978

CE 016 639

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Chapter 1

INTRODUCTION

Developments in the field of electronics have been so rapid in the last decade that frequently the interval between development and marketing results in obsolsence almost as soon as equipment reaches the consumer. Often times commercially available instruments, at moderate cost, perform measurements quite close to the accuracies previously attained only at the National Bureau of Standards. The conversion from analogue to digital measurement techniques and displays is apparent to the American public in abundant sales of digital watches replacing the common dial watch with its analogue display.

These factors of continual change in the electronics field present a perplexing problem for the electronics educator in maintaining current curriculum. This study attempts to determine the appropriate competencies, knowledges and equipment necessary to maintain a current electronics instrument course in the electronics associate degree program.

Nature and Scope of the Problem

Statement of the Problem

There is, at present, no clearly defined set of

priorities on which to base the curriculum of an instruments course. Although the purpose of the associate degree electronics program is to prepare technicians for job entry level skills, no reliable feedback system exists from the job market to inform the vocational school of its needs.

Instructors of electronics programs, such as this writer, are aware that employers' expectations and the demands industry places on new graduates are constantly changing. Feedback from the job world, however, has been limited and sporadic. Advisory committees, visits from past graduates, and incidental conversations with industrial representatives give the instructor many concerns about the relevance of the instruments curriculum but not a comprehensive objective information base on which to prioritize an instruments curriculum. The essence of the problem is that instructors of associate degree electronic programs have difficulty determining the course content of the instruments course partially due to inadequate feedback from the world of work and partially due to a serious deficiency of an adequate text for the associate degree level.

Research Goals

The primary goal of this research was to identify instrument and competency priorities as seen by employers and technicians thereby providing a relevant framework for evaluation of existing curriculum priorities. The

investigator believes that those employers and electronics profressionals who are currently working today are in the best position to identify the knowledges needed for the professionals who will soon join them. A basic concept of vocational education--that of preparing technical workers for entry-level industry oriented skills--is reflected in this goal.

A second goal of the study was to provide the instructor with information on which to base curriculum changes in preparing for future industry needs. Industry representatitves, familiar with the long-term planning goals of their companies, should be able to inform the instructor of future trends in electronics technology and the skills of tomorrow's electronics graduate. The third goal of this study was to provide the instructor and administration with information on which to base equipment procurement requests. Instrumentation equipment is expensive, and administration must justify this expense in light of curriculum priorities.

The fourth goal of this research was to provide text manufacturers with the data necessary to engage an author in preparing an appropriate instruments text for use in two year associate degree programs. The final goal of this research was to maintain communication between WVTAE schools and employers. This investigator believes that on-going communication between education and industry is necessary to fulfill the goals of the vocational education

system--to prepare the graduate for the world of work.

These five goals: (1) identify present priorities of instruments and related competencies, (2) establish data for a curriculum that will prepare graduates for future needs, (3) establish equipment procurement priorities, (4) provide data on which to publish a text, and (5) maintain communication with industry; were, in part, met by the research as discussed in the results section of this paper.

Background of the Study

Presently, in the Wisconsin Vocational Educational System, electronic instruments are typically studies as either a one semester course or as a complete instruments program. The graduate of the associate degree electronics program is expected to enter the world of work with current knowledge of basic instruments used for measurements, standards, testing, and troubleshooting. Some employers will expect the graduate to have general knowledge of several instruments while other employers will want him to develop expertise in a few instruments at specific levels of competency.

Most VTAE schools in Wisconsin present the study of instruments in the form of a one semester course. Faced with a wide variety of instruments with varying degrees of technical complexity, the instructor must decide which instruments and what competencies are the most essential ingredients of such a course.

Significance of the Study

The investigator became interested in this problem approximately four years ago when he was assigned to teach the instruments course at Madison Area Technical College. At that time the course was a "clean up" course--containing concepts that had been left over from other coursework.

Upon pursuing coursework at University of Wisconsin-Stout, the investigator studied task analysis as a framework for an organized analysis of such a curriculum problem. The task analysis approach appeared to be the best tool for obtaining, organizing and prioritizing data; thereby lending insight to a problem such as this. The investigator also saw that the task analysis approach lends itself to present and future cooperation between vocational education and industry. Finally it appears that the data gathered can be compared and contrasted. Prioritization of course content can be achieved to structure the objectives for an electronic instruments course.

The investigator felt that an important variation in the present study over that of similar studies completed in Wisconsin was the request for company/site-specific data. Company/site-specific is meant to convey the concept that the researcher wanted data relating only to the respondents' needs at the particular facility of the visited site. The investigator felt this concept is important because only data that is immediately verifiable is included in the study. It was intended that this would

eliminate perceived opinions not based on actual experiences. The random sample technique should have adequately represented all specialties in a scientifically verifiable manner--thereby eliminating the need for inaccurate responses due to biases or misconceptions.

One basic change was made from the task analysis format--the investigator did a competency analysis instead of a task analysis. It was the concern of this investigator that the analysis of tasks relating to such a complex job specialty would result in oversimplification and thereby omit several taxonomies as defined by Bloom.[1] By investigating competencies, the instructor can begin to determine levels of cognitive domain taxonomies to be included in educational objectives.

The primary significance of this study was to improve and verify the relevancy of the electronic instruments course as taught by the investigator. Specifically significant about this study is the attempt to verify the need for including taxonomies at the analysis, synthesis and evaluation level.

Study Questions

This study, then, is an organized approach to obtain current information on the present and future

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[1]Benjamin S. Bloom, Taxonomy of Educational Objectives (New York: Longmans, Green & Co., 1956), pp. 62-185.

expectations of instrumentation competency for newly graduated technicians. By pursuing this study, the investigator planned to answer the following questions:

1. What instruments should the technician be capable of applying to job entry responsibilities? The investigator would like to identify specific instruments most commonly used by the wide varieties of employers in the job market. It is expected that this study should differentiate between the most commonly used instruments and those instruments that are used infrequently or used only by certain specialized employers.

2. What competencies, with these instruments, do employers and technicians expect of the newly graduated technician? Due to the time limitations of the instruments course, an instructor cannot develop a detailed curriculum on the usage of every instrument at all levels of competency. Answers to this question should help the instructor plan his classroom time more effectively.

3. Do employers and technicians hold similar views concerning instruments and competency levels that are needed in the world of work? At this point, the investigator must assume the views of the employer and the technician are similar. However it is plausible that the technician, the person doing the job, and the employer, the person supervising the job, may hold different views because of their different involvement in the job situation. For that reason it is important to validate this assumption.

Instructors setting curriculum priorities from this study should be aware of the differing views, if they exist. It is intended that this study will be an asset to the instrumentations course instructor as he sets his curriculum priorities. This investigator believes that the results of this study will provide the needed feedback that has been missing from other types of curriculum planning for the instruments course.

Limitations of the Study

In order to clearly delineate the restrictions and conditions under which this study was pursued, the investigator has recognized several limitations as affecting either the data or the results of the study. Beyond the obvious limitations of time and money which affect all scholastic studies, this investigator has recognized three limitations introduced by the choice of population that was studied, one limitation related to the survey instrument that was used, and two limitations entered from the survey procedures. These limitations are presented here to allow others to apply, extrapolate or generalize the data and findings with due caution realizing the framework in which the study was implemented.

The investigator limited the population from which the random sample was drawn in two ways: (1) geographic area, and (2) known employers of WVTAE graduates during the 1972-1977 period. The geographic boundaries of the

population included the state of Wisconsin and the Minneapolis-St. Paul area. This study may not be relevant in other areas of the country such as Texas where military electronics and government work predominate in the job market.

The second population limitation imposed by the investigator was that a random sample of all Wisconsin employers was not included. Only employers who have hired WVTAE electronics graduates in the last five years were chosen. Predominant in this is the concern that the employers, not included in the study, may not hire WVTAE graduates because of shortcomings in our curriculum and this study may therefore ignore an important resource. This study had no contact with new job markets that may be hiring our graduates in the future.

Another limitation affecting the population to be studied concerned the numbers of employers that were referred for purposes of the study. The investigator requested each of the fourteen districts to submit a list of all employers of their electronics graduates for the last five years--although all districts responded, some districts were unable to provide complete information.

The investigator recognized that his own biases entered when formulating the survey instrument with his choice of electronic instruments and competencies. The investigator believes that this limitation was partially solved by reviewing the survey instrument with several

different representatives of education and industry (see p. 24).

During the data-gathering phase of the study, another limitation was recognized--that some companies were only able to provide either the technician or the employer but not both. One WVTAE district whose name was drawn in the random sample chose not to participate in the study at a point in time when replacement by an alternate was not feasible. The time frame for the gathering of the data could be recognized as a limiting factor of the study as all data was gathered during the summer and fall of 1977.

Although these limitations may have had some effect on the results of the study, it is believed that the analysis and evaluation of the data will yield meaningful results for the electronics instructor in the associate degree program. The investigator obtained construct validity by comparing the results of his study with the results of the Hagan study (see p. 37 for this comparison). It is recommended that interpretation of the results of this study should be done keeping in mind the limitations of the study as specified above.

Definition of Terms

While planning and implementing this study, the investigator recognized the need to define those terms that are most crucial in interpretation of the study or terms that have a variety of meanings in their common usage.

The following are terms that needed defining for the purposes of this study:

WVTAE or Wisconsin Vocational, Technical, and Adult Education - The vocational education system of the state of Wisconsin. Specifically this is interpreted as the vocational system of sixteen Wisconsin districts of which fourteen districts have an electronics program that participated in this study.

Electronics Technician - A professional employee that applies electronic theory and related subjects to test and modify developmental or operational electronics machinery and electronic control equipment and circuitry under the direction of an electronics engineer or senior supervisor. He assembles and tests experimental devices, modifies electronic prototypes, and troubleshoots operational equipment. This job requires an ability to plan and develop wiring diagrams and layout drawings. He also directs personnel performing routine installation, testing and maintenance.

Competency - The quality or state of being functionally adequate or of having sufficient knowledge, judgement, skill or strength to perform a particular duty.[2]

It was felt by the investigator that other terminology in this study is used as common usage for the

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[2]Phillip Babcock Gove, PhD, ed. Webster's 3rd New International Dictionary-Unabridged, (Springfield, Mass: G&C Merriam Company.)

academic world and does not require a definition for meaningful understanding.

Summary

It has been asserted that rapidly advancing technology in the electronics field poses special problems for the electronics instructor in instrumentation. In his attempts to keep the content of the instruments course current, a dependable source of feedback from the world of work has been lacking.

This study is designed to strengthen the feedback from the world of work by requesting employers and technicians to identify instruments and competencies that are the most necessary knowledges for the newly graduated electronics technician. The task analysis approach has been modified to a competency analysis in order to avoid oversimplification of the complex jobs in the electronics specialities. From this feedback, it is anticipated that the electronics instructor will be able to prioritize the instruments curriculum as well as advise school administration as to the future needs of his department.

Therefore the goals of this study include identifying instrument priorities, providing information on future trends, providng information for equipment procurement, providing data for text manufacturers, and maintaining communication between WVTAE schools and employers. The study questions have been developed pursuant to these goals.

Chapter 2

REVIEW OF LITERATURE

A review of the literature has shown a deficit in information on priority to be given competencies in electronic instrumentation. However it has been stated that there is a need for curriculum development centered around cooperation between industry and the educational institutions. This is reflected in Robert C. G. Williams' statement, "For efficient and cost effective development, the educational world and industry . . . must learn to work in partnership."[1] A competency analysis approach can be an effective tool in establishing this partnership.

Ohio State University recognized this need in developing sixty-one different occupation analyses for the purpose of training vocational educators in these analysis techniques.[2] Ohio State's research indicated several distinct advantages in this approach. They included: (1) economy, (2) quantifiable information, (3) because the data is quantifiable, it can be adapted to computer analysis,

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[1]Robert C. G. Williams, "Education and Industry-A Cooperative Effort," IEEE Transactions on Education, E-18, (May, 1975), 71.

[2]William Ashley, Ed., An Analysis of the Telecommunications Occupation (Columbus: Ohio State University Press, 1974), p. 3.

(4) it can be statistically validated, and (5) it yields accurate information.[3]

In developing the competencies presented in the analysis related to this study, the investigator expanded on the performance knowledges, equipment, and materials as developed in the Ohio State documents relating to telecommunications and radio servicing. The required knowledges, as presented in the Oregon Board of Education occupational Cluster Guide, were incorporated in the development of this research document.[4]

The above two mentioned resources have limited relevance to the investigator's proposal in that the Ohio State documents specifically addressed themselves to the fields of telecommunications and radio servicing. The Oregon State analysis is primarily an occupational cluster guide for the total electrical-electronics job cluster. Its purpose is to determine "the basic skills and knowledges related to broad occupational areas."[5] In this case the word basic is of primary importance in that the Oregon study is addressing itself to competencies well below the level required in this study.

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[3]W. H. Melching and S. D. Borcher, Procedures for Constructing and Using Task Inventories (Columbus: Ohio State University Press, 1973) p. 12.

[4]Oregon Department of Education, Curriculum Guide for Electricity-Electronics (Eugene, State of Oregon Press, 1969) pp. 18-20.

[5]Ibid., p. ii.

Four books were used as a base for determining the competencies to be included in the questionnaire. They were: (1) C. T. Baldwin, Fundamentals of Electrical Measurements. New York: Unger, 1961, (2) Clyde F. Coombs, Jr., Ed., Basic Electronic Instrument Handbook. New York: McGraw-Hill, 1972, (3) William David Cooper, Electronic Instrumentation and Measurement Techniques, Englewood Cliffs, N.J. Prentice-Hall, 1970, and (4) Abraham Marcus and John D. Link, Measurements for Technicians. Englewood Cliffs, N.J.: Prentice-Hall, 1971.

A more relevant study was proposed in 1974 by James Flieger, electronics instructor at Midstate Technical Institute, Wisconsin Rapids, Wisconsin.[6] He has developed a task analysis questionnaire for an entire instruments curriculum (both mechanical and electronic). Mr. Flieger's questionnaire indicates a concern for updating the electronics instruments curriculum by use of the task analysis approach. Should he distribute his questionnaire, it will be linked to the employers within that vocational school district. With that areas's emphasis of paper manufacturing, his findings would likely carry limited applicability to a composite picture of the demands of industry throughout Wisconsin. The investigator's study was a random sample from the spectrum of industries

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[6]James Flieger, "Task Analysis of the Instrumentation Technician" (unpublished Plan A proposal, University of Wisconsin--Stout, 1974).

throughout the state of Wisconsin as detailed in the methodology.

The high level of importance that employers place on instruments in the electronics curriculum was established in the study by Robert E. O. Hagan.[7] Seventy-seven per cent of the respondents indicated that instruments and measurements knowledge is "essential" to the associate degree graduate. This ranked fourth in the category of "essential" knowledges.

Hagan's study included five instruments-related topics that are similar to items on the present study. These items can be correlated with the results of the present study to establish criterion related validity. In Hagan's study the indicated percentages of eighty-one respondents designated the listed competencies as essential.

1. Oscilloscope measurements - approximately 70%
2. Voltage measurements with voltmeter - 90%
3. Resistance measurements with ohmeter - 89%
4. Signal injection with signal generator - 63%
5. Frequency measurements with frequency meter - 52%[8]

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[7]Robert E. O. Hagan, "Evaluation of Electronics Curriculum in Terms of Employer's Rating of Job Performance of Former Students," (unpublished project, State of Wisconsin, Department of Vocational, Technical and Adult Education, 1972) p. 23-25.

[8]Ibid.

[9]Ibid., p. 32.

In the same study, three electronic areas were questioned as to adequacy of training. Of these three, application of electronic testing equipment rated as the most lacking in adequate training background.[9] The present study, should help the Wisconsin vocational school administrators and instructors in improving the curriculum to more closely align with the needs of employers.

The competency analysis approach can be an effective tool in identifying competencies and their priorities as related to electronic instruments. An added benefit of the competency analysis approach is that it has been an instrument to enhance communication between educators and representatives of industry.

Chapter 3

METHODOLOGY

The teaching of an instruments course in an associate degree electronics program is a complex situation. Instructors of such a course find it hard to keep up-to-date on employers' expectations of newly graduated electronics technicians at job entry employment. This study is a formal attempt to receive feedback from employer supervisors and technicians by means of competency analysis. It was felt that the results of this study would be used to improve the present curriculum of instruments courses as well as indicate future trends of instrumentation usage.

The investigator considered the following items to be essential to the design of the study:

1. Select a population that would accurately represent the varieties of employers of electronics technicians in Wisconsin. Electronics technicians, like most professional and technical workers, have excellent opportunity for job mobility and the technical school has an obligation to prepare technicians for the greatest variety of job situations. It is possible that a corporate industry in a large urban center will want different

competencies from its technicians than a small electronics shop in a predominantly rural area.

2. Receive accurate information from the random sample of population. It is imperative that (within the realistic limits of time and money) every effort be made to design the survey instrument in such a manner as not to confuse the respondent or be directive in leading the responses. The validity of the obtained data can be effected by ambiguous, leading or poorly designed questions and will only amplify the problem--not solve it.

3. Analyse, compile and report the results so that the information is presented in a format that is accurate and descriptive of the competencies required of electronics technicians. This information should be presented in such a manner that other instructors, VTAE administrators, and book publishers can, with little effort, make decisions about curriculum and equipment.

The following description of the methods and procedures provide background so that other researchers could validate this study by duplication of research. This description should also clarify the limits and/or appropriateness of this study to specific applications. The methodological procedures are described under four major areas. These areas are (1) selection of the sampling population, (2) design of the survey instrument, (3) data collection, and (4) data analysis procedures.

Selection of the Sampling Population

Employer supervisors of graduates from existing vocational programs and technicians employed by these firms provide a viable source of information. These employer supervisors and technicians are qualified to designate the current competencies, skills, and knowledges necessary for employment of a recently graduated technician. Since success in business would require skill in predicting future trends, these people would seem to be qualified to make appropriate suggestions on the necessary qualifications of graduates now entering the program and entering the world of work two years hence.

Selection of Participating Employers and Technicians

A list of occupation-related employers who have hired graduates during the last five years (1973-1977) was supplied by the fourteen WVTAE schools in the state. The lists, all from schools offering a two-year program in electronics or instrumentation, ranged from six to fifty-nine employers. The study had the assistance of Mr. Eugene Lehrman and the State of Wisconsin Department of Vocational, Technical and Adult Education. Fourteen schools responded with employer lists ranging from six to fifty-nine employers.

In preparation for taking the random sample, all lists were reviewed to delete duplication; thereby insuring that each employer was entered only once in the original population. Due to cost and time elements, all out-of-state

employers were eliminated except those in Minneapolis-St. Paul. Minneapolis-St. Paul was included upon the recommendation of WVTAE because a large percentage of graduates (in the central western portion of Wisconsin) are employed in that area. After assigning each employer a number, 251 Wisconsin employers were sampled to obtain a survey population of twenty-five firms and nine alternates. Three Minneapolis-St. Paul firms were also drawn by random sample from a list of seventeen Minneapolis-St. Paul employers submitted by WVTAE schools.

Each of these thirty-seven employers was contacted by phone. In this telephone conversation, the following points were covered:

1. The researcher identified himself.
2. The purpose of the study was related.
3. The method of choice of participants was explained.
4. Verification that the employer hires associate degree technicians was obtained.
5. A request was made for involvement of the employer in the study.
6. Permission was received to send Mr. Lehrman's letter of introduction, the investigator's cover letter, and a copy of the questionnaire. (See Appendix A and B for these papers.)
7. The name and correct address of a contact person was obtained.

Nine of the employers, when contacted by phone, had to be elimiated for the following reasons:

1. Don't hire electrical technicians at present--three.

2. Stopped manufacturing electrical-related equipment--therefore don't hire--one.

3. Technician going to school at Stout--one.

4. Closed this office--one.

5. Don't hire associate degree electrical technicians--three.

In examining a profile of the industries and businesses that were selected by random sample and subsequently participated in the study, it was found that a wide variety of employers and technicians were represented. The Milwaukee-Racine industrial area was represented by twelve businesses and industrial concerns while the Minneapolis-St. Paul area, the Madison area, and the Fox River Valley area each offered three. These grouped samples, plus the more dispersed samples, represented all areas of the state except the southwestern portion.

In a brief review of the business and industrial firms located in southwestern Wisconsin, the researcher determined that the spectrum of employers included had similar characteristics of size, complexity and electronic sophistication as the employers in the southwestern portion of the state. Therefore it was felt that no significant

loss of information would occur due to this void in the ramdon sample.

Representative industries in Wisconsin and the Minneapolis-St. Paul area included paper manufacturing, computer companies, heavy industry, a railroad, small appliance manufacturing, and electrical power companies. Television and radio servicing, stereo and small appliance repair, a VTAE school, a hospital, and a university supplied the remaining sample.

A list of employers, identified by WVTAE schools, was the basis of a random sample. Several firms of this sample were eliminated for reasons specified. It was shown that a broad spectrum of business and industry participated in the study. The specific needs of these firms represent a scientifically accurate base as opposed to the "perceived" opinions often requested in questionnaires. All geographic areas of the state were fairly well represented except the southwest section.

Design of the Survey Instrument

The design of the survey instrument included two identifiable stages. The first stage was a planning stage in which the investigator reviewed task analysis notes and texts to establish the format for the questionnaire and reviewed instrument texts to develop a basic set of competencies and instruments. The second stage was an advisory and pilot stage in which the investigator contacted

an advisory group to review and modify the survey instrument. These stages are more explicitly described in the following paragraphs.

During an earlier planning stage, the investigator did a review of pertinent textbooks to establish a basic list of electronic instruments and identify the competencies that were addressed in the texts. From this review and relying upon five years of electronic teaching experience, four years of industrial experience, two years of research experience and four years as an electronics technician in the military; the investigator planned a working copy of the survey instrument.

To further refine and adapt this instrument to the needs and conditions in Wisconsin, the investigator relied upon the advice of the following members of technical education and industry: (1) Richard Cashwell, Nuclear Reactor Center, University of Wisconsin; (2) Harry Miller, Instrumentation Systems Center, University of Wisconsin; (3) Jack Birong, Instructor, Madison Area Technical College; and (4) Al Schultz, Gilson Medical Electronics, Middleton, Wisconsin.

The advisors filled out the questionnaire so that confusing or misleading items could be identified. Each advisor was requested to make an independent judgement as he reviewed the working copy of the questionnaire. The advisors were reminded that this was a list of instruments and competencies which were important for <u>all</u> employers and

technicians in Wisconsin.

Based upon the judgement of the advisors, the working copy of the questionnaire was then revised to add those instruments or competencies that were judged to be more or less important to the total picture of instruments knowledge for electronics technicians and delete those judged to be unimportant. The investigator used the advisory group's responses as a pilot study of the questionnaire.

The questionnaire prepared to obtain the responses of employers and their technicians consisted of three pages. (See Appendix B) The major portion of the questionnaire consists of twelve competencies which are applied to twenty-eight instruments. On one questionnaire, the respondents were requested to indicate the "frequency of use" of that competency for that respective instrument. The following numerical criterion was (1) no use, (2) yearly, (3) monthly, (4) weekly and (5) daily.

On the second questionnaire (a duplicate of the first questionnaire) the respondents were requested to indicate the "level of importance" of knowledge concerning that competency as applied to that particular instrument. The following numerical criterion was (1) no importance, (2) slightly important, (3) average importance, (4) very important, and (5) essential.

On the third questionnaire, the respondents were

requested to indicate the importance of knowledge and the frequency of usage for selected "concepts general to the use of all measurement instruments." Space was allowed on all three sheets for the respondent to add instruments. By this process, the three resulting questionnaires were developed and subsequently used for data collection.

Data Collection

Data Collection Overview

During the summer and fall of 1978, the writer traveled throughout Wisconsin and to the Minneapolis-St. Paul area to complete the survey instrument. Before traveling to a business or industrial site, the investigator phoned the company to schedule a mutually convenient time (for both a technician and and an employee supervisor) to complete the survey instrument.

Prior to the scheduled date, each subject was sent a letter explaining the purpose of the study and a copy of the survey instrument. The employer/supervisor selected the electronics technician for participation in the study.

On the scheduled date, the survey instrument was completed by the employer/supervisor and the electronics technician in separate sessions. The investigator, or a knowledgable assistant, was present at all sessions when the survey instrument was answered. This provided the same clarifications to all respondents and answered any questions that arose during the completion of the survey

instrument. It was found that completion of the instrument took each respondent approximately one and one-half hours. At the conclusion of the session, the respondent was thanked for his cooperation and offered a copy of the results of the study.

At several business or industrial sites, either the employer/supervisor or the technician was unable to answer the questionnaire because of previous job commitments or unanticipated changes in his work schedule. Near the end of the data collection phase of the study, it became impossible for the investigator to travel to one of the job sites for completion of the survey instrument. These respondents were sent the questionnaires and then telephoned to receive their instructions and answer any questions they had. Twenty-two employer/supervisors and twenty-one technicians representing twenty-four firms completed the survey of the sampled population in a three month period.

Data Collection Procedure

During the process of completing the questionnaire, the researcher employed two research assistants--one of which was involved in two technician and one supervisor contact. The remaining thirty-seven contacts were made by the primary investigator. To maintain a record of the oral communication, the investigator requested the respondent's permission to use a tape recorder. No respondent refused this request.

At the beginning of the contact session, the respondent was presented with two identical questionnaire sheets. The researcher explained that the form would be completed twice. First the Frequency of Use form would be completed for each competency level relating to any instrument used in that firm. It was pointed out that the researcher wanted information specific to that firm at the visited site, company/site specific; not information that the respondent perceived as applicable to electronics technology in other applications. All boxes left blank would be considered to be rated "1--no use." The Level of Importance ranks were marked out at the top of the page so that the researcher could readily identify the data as being Frequency of Use.

During the earlier part of the data collection process, it became apparent that three clarifications were necessary and thereafter were brought out as a part of the initial discussion:

1. Competency #1 was less inclusive than Competency #2 and therefore it should be understood that the respondent was mis-understanding the competency statement should he rate Competency #2 higher than Competency #1. An example was given using the volt ohmeter to clarify the concept.

2. An example of Competency #3 was presented. The example used was that of the voltmeter causing circuit loading.

3. The key difference between Competency #8 and Competency #9 were the words "design" and "transducer." In Competency #8, we are specifically asking, "Does the technician do interface design?" In Competency #9, the key idea is transducers--"Should transducers be taught as a part of an instruments course?" "Are transducers used in conjunction with electronic instruments to the extent that they should be included in the instruments course?"

Any further discussion was specific to queries and comments initiated by the respondent.

After completion of the Frequency of Use rankings, a blank copy of this same questionnaire was presented to the respondents and Frequency of Use ratings were marked out at the top of the paper so the respondent would concentrate on the Level of Knowledge ratings. At this point the investigator emphasized that instruments, not presently used by the company, might be important to improving efficiency or quality and therefore should be considered according to that Level of Importance, not according to the existing instruments inventory and competency expectations.

Unless a direct correlation between Frequency of Use and Level of Importance exists, the respondent was requested to separate the two concepts. A typical example was that of Competency #10. Perhaps the respondent has not been exposed to a new instrument often enough to respond with other than a minimal Frequency of

Use--however, given a new instrument, he would expect the technician to be able to use the instruction manual and correctly apply the instrument. Therefore, Level of Importance for this competency would be rated high while Frequency of Use would be low. Any additional dialogue was at the initiative of the respondent.

In completing the third page the researcher pointed out that the Frequency of Use and Level of Importance ratings, used in the earlier parts of the study, should be implemented on the present study.

At the termination of the session, it was obvious that the respondents had invested a great deal of energy in the process of completing the questionnaire. Due to this difficulty, the researcher eliminated a planned portion of the study that would have compiled data for specific job-related laboratory exercises. The data obtained during these sessions was later analyzed to fulfill the goals of the study.

Data Analysis

The goals of the study, as listed in Chapter 1, provided the framework for the data analysis. The four goals, requiring data for satisfaction, demand identical quantification of the responses. Therefore the data analysis was quantified once, and applied to each of the four goals without further analysis. The analysis also yielded an instrument priority ranking from combined

results of employer/supervisors and technicians.

In analyzing the data to meet the goals of the study, each response in the matrix of the questionnaire was quantified to determine the mean and the standard deviation with separate calculations and results for the technicians and for the supervisors. If a standard deviation less than 1.2 was achieved for any response, that particular mean was applied according to the following criterion:

Mean	S.D.		
4.5 to 5.0	<1.2	Essential	Include
3.5 to 4.5	<1.2	Important/Essential	Include
2.5 to 3.5	<1.2	Important	Include
1.5 to 2.5	<1.2	Marginal	Exclude
0.5 to 1.5	<1.2	Unimportant	Exclude

The same rules were applied to the Level of Importance information and to the Frequency of Use information. However, Level of Importance was weighted more heavily when an uncertainty arose. If the mean response of the technicians varied by more than four per cent from the mean response of the employer/supervisors, the response was brought to the advisory committee for evaluation. Any response in the matrix having a standard deviation greater than 1.2 was also evaluated by the advisory committee to determine the appropriate dispensation.

To establish a basic hierarchy of instrument

priorities, all responses (employer/supervisor and technician) were combined. The mean of these combined responses was determined for each instrument at the first competency level. These means were then prioritized according to their weight. The methods of analysis, incorporated in this section, were then applied to formulate the conclusions in the remainder of the study.

Summary

This study is an investigation into the necessary instruments and competencies that should be a part of the associate degree electronics curriculum. Data was obtained from employer/supervisors and electronics technicians of twenty-four Wisconsin and Minnesota-based industrial firms, businesses and schools.

The sampling of population was selected by a random sample of twenty-five firms from lists of employers submitted by all WVTAE schools. The survey instrument, formulated by the investigator and critiqued by representatives of technical education and industry, was a three page questionnaire. Respondents ranked the Frequency of Usage and the Level of Importance relating to twelve competencies and to twenty-four instruments.

The data was analyzed by determining the mean and standard deviation of each competency for each instrument. Insginificant competencies and instruments were then

eliminated from further consideration and the remaining instruments and competencies were then prioritized to demonstrate which instruments and competencies should be considered components of an associate degree instruments course.

Chapter 4

ANALYSIS OF THE DATA

This study was implemented to identify how employer/supervisors and technicians prioritize electronic instruments and competencies relating to them in order to arrive at their expectations of associate degree holders at the job-entry level. The employers of electronics technicians were chosen by random sample from a population of employers hiring WVTAE graduates. The goal of the study was to inform a variety of education-related personnel-- instructors, administrators and text book authors-- of the relative importance of these instruments and competencies.

The study was carried out during the summer and fall of 1977. Twenty-two employer/supervisors and twenty-one technicians, representing twenty-four companies, completed a three page questionnaire. On this survey instrument the respondents were requested to rank the Frequency of Use and the Level of Importance for twelve competencies applied to twenty-eight instruments.

This chapter analyzes the data to establish criterion-related validity, to present an overview of the data, to apply the data to an instruments course, and to develop an equipment procurement list.

Establishment of Criterion-Related Validity

In establishing criterion-related validity, Hagan's study (1972) was compared with the present study. Hagan's study indicated percentages of respondents giving an essential priority to the use of four different instruments, comparable to the four instruments in the present study. In making this comparison, the responses on the Level of Importance Questionnaire were analyzed relating to Competency 1 (Utilizes less than the total capacity of the instrument). To determine the percentage of the total responses given the ranking of five (essential), the data from the technicians and employer/supervisors was combined. Table 1 shows the comparison of these four items on the Hagan study to the present study.

An obvious question to ask about the results shown below would be, "Why is there such a marked difference in the total percentages?" Two factors are apparent in responding to this question: Hagan's study apparently did not use a random sample technique and evaluation of employer needs was not company/site specific. First, Hagan's comment that "he selected it" in referring to his sample population implies that Hagan used his professional judgement in selecting employers for his sample population. This method of surveying employers would not likely have the broad spectrum of responses that a random sample, used in the present study, would produce. Consequently this

potentially biased population might have centered around firms that make above average use of electronic instruments --resulting in the higher percentage ratings.

The second factor could be attributed to the instructions provided with the questionnaire. Unlike the Hagan study, the present study included instructions to evaluate only the needs of the participating firm at the visited site-- a company/site-specific response. The importance of this instruction became evident when the investigator was regularly queried by the respondent to verify that the replies were to be company/site-specific. These respondents indicated that they would respond differently if their perceptions of an electronics technician in other employment situations were to be included. If such specific directions were not included in Hagan's study, it is likely that his respondents included perceived needs as well as immediately verifiable needs. The investigator feels that the Level of Importance data would have resulted in uniformly higher averages had the respondents included other than company/site-specific information.

Based on an understanding of the methodological differences in these two studies, Table 1 can be used to establish criterion-related validity. Both studies show the highest level of priority is given to the volt ohmeter. The hierarchy of Hagan's instruments correlates with the present study although the percentages are

Table 1

Comparison of Hagan's Study with the Present Study for Criterion-Related Validity

Hagan's Study Proficiency is Essential		Present Study Competency is Essential	
Voltmeter	90%	Voltmeter	70%
Oscilloscope	70%	Oscilloscope	51%
Signal Generator	63%	Signal Generator	23%
Frequency Meter	52%	Frequency Meter	16%

different. This indicates criterion-related validity is evident in the two studies.

Data Analysis

In considering the data obtained in this study, it is important to keep in mind the description of the original sample population as well as the profile of the random sample described in the methodology. Attention must also be given to the limitations of the study when applying or extrapolating information contained in this chapter. The reader is reminded that twenty-four of the twenty-five qualified companies participated in the study. The data included the responses of twenty-two employer/ supervisors and twenty-one technicians for a total of forty-three respondents representing twenty-four companies.

Overview of the Data

An overview of the data indicates that some generalizations can be made about certain competency levels without regard to specific instruments. Competencies 8, 9, 10 and 11 clearly fall into this category. Due to the low Level of Importance throughout the data, Competencies 8, 9, and 11 should be omitted from the curriculum of an instruments course. Although employers put less importance than technicians on Competency 10 (the application of instruction manuals to the use of an instrument), it is clear that the associate degree program should develop a student's ability to assimilate (independently) information from technical manuals. Competency 7 (the theory of operation of instruments) appears to be of marginal value although the employer/supervisors responded with slightly higher averages than the technicians.

Concepts (third questionnaire) that appear to have highly conclusive data are safety grounding, A.C. power grounds, (high Level of Importance) and common mode interference (negligable Level of Importance). It is immediately apparent that the Occulational Safety and Health Act has caused a high level of awareness for safety considerations and may be responsible for these significant answers. It was felt that the low Level of Importance attributed to common mode interference may have been due to a lack of clear understanding of this concept on the part of the respondents.

An overview of the data would appear to exempt eight instruments from the instruments curriculum (digital oscilloscope, curve tracer, tube checker, transistor checker, signal analyzer, radiation instruments and powermeter R.F.) The investigator feels that additional consideration should be given to the curve tracer. Although the curve tracer ranks very low as to the Level of Importance for the work environment, its use as a teaching aid would probably override the lessor importance found in this study.

To aid in the decision-making process, tables showing the hierarchy of "Importance of Concepts General to the Use of Electronic Instruments" and the hierarchy of "Importance of Specific Instruments" were developed. Competencies cannot be prioritized in general as the data presentation indicates. The idiosyncrasies of specific instruments requires varied competency levels.

Ranking of Instruments

Table 2 ranks the instruments by mean scores (from Level of Importance responses) with combined data from employer/supervisors and technicians. There is a decisive break in the mean score below the top five instruments. The mean score for the instruments ranked sixth through fifteenth does not have a significant variation for differentiation in priorities. Considering the large standard deviation (greater than 1.0), a change in mean of 0.1 point is not significant.

Thus Table 2 reduces into two groups of instruments. One group, comprised of the top five ranked instruments, should definitely be included in an associate degree electronics curriculum. The other group, comprised of the remaining list of instruments, requires further analysis. (Seven instruments have already been eliminated from this table due to their low mean score - less than 1.0).

Application of the Data to Course Development

The data analysis of the prior section provides a foundation for course planning. Tables 2 and 3, used in conjunction with the results in Tables 4-9, are the basis for the course decisions as delineated in this section.

These course decisions are directed toward a third semester course in a four semester associate degree electronics program. The prerequisites for this course would be D.C. and A.C. circuits, and concurrent enrollment in a semiconductor devices course. A weekly schedule of three one-hour lecture sessions and a three-hour laboratory would be established. The course objectives will be determined through the following application of the data.

The instruments to be used as the core of this instruments course are: (1) the digital voltmeter, (2) the analogue voltmeter, (3) the oscilloscope with triggered sweep, (4) the D.C. power supply, and (5) recorders and printers. In referring to the data analysis section, these

Table 2

Instrument Priorities Obtained in Mean Ratings from Combined Employer/Supervisor and Technician Data
(Forty-three respondents)

	Response	Mean	Rank
1.	Digital Voltmeter	4.1	1
2.	Analogue Voltmeter	4.1	1
3.	Oscilloscope with triggered sweep	3.8	3
4.	D.C. Power Supply	3.8	3
5.	Recorders & Printers	3.3	5
6.	Oscilloscope 20 Mhz.	2.9	6
7.	Microprocessor Test Instruments	2.8	7
8.	Signal Generator	2.8	7
9.	Bridge Measurement	2.6	9
10.	Db Meter	2.5	10
11.	Pulse Generator	2.5	10
12.	Decade Counter	2.4	12
13.	Oscilloscope without triggered sweep	2.4	12
14.	Watt Meter	2.35	14
15.	Function Generator	2.3	15
16.	Standards	2.3	15

instruments were shown to have a significantly distinct ranking of importance to warrant special emphasis in the instruments course. The investigator would include these five instruments as the major emphasis of the first nine weeks of an eighteen week semester course.

Concepts relating to grounding (Table 3) would be included with this first section of the course. These concepts are (1) safety grounding, (2) A.C. power ground, (3) A.C. power instruments (grounding), (4) ground loop and (5) multiple ground. As can be seen from Table 3A, all of these concepts fell within the essential/important rating and should be included within the course content. Although multiple ground had a standard deviation of greater than 1.2, the advising committee determined that this concept should be included. In making its decision, the Advisory Committee noted that the Frequency of Use had a high enough mean to warrant special consideration. Battery powered instruments and high current grounds were not included because of their large standard deviation.

All five concepts relating to accuracy would also be included in this first nine weeks. These concepts include: (1) digital versus analogue readout, (2) precision, (3) percent error, (4) significant digits, and (5) identifying sources of measurement error. As noted on Table 3, these concepts also fell within the essential/important rating. Percent error had a standard deviation greater than 1.2, but had a significant frequency of use and there-

fore was included by the Advisory Committee.

Effects of input and output impedence on the measurement, although presented under a separate heading on the questionnaire, have significant impact on the accuracy of instrument readings or the proper interpretation of readings. Since the mean rating for this concept fell within the essential/important category, this concept was included with the accuracy grouping in the course development.

The concepts relating to grounding and accuracy were included in the early portion of the semester because the students would have sufficient background to be able to assimilate these concepts. Understanding of remaining concepts would require knowledge currently be learned in related courses.

Using this overview, specific course format was developed for the first nine week segment:

I. Weeks 1-3
   A. Instruments--digital and analogue voltmeter
      1. Competency 1--Utilizes less than the total capacity of the instrument
      2. Competency 2--Utilizies all instrument functions in standard applications
      3. Competency 3--Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument

Table 3A

Concepts Necessary in Electronic Instrumentation According to the Mean Ranking of Level of Importance Responses (Standard Deviation <1.2)

Technician Mean	Employer/ Supervisor Mean	Concept
4.6	4.4	Safety grounding
4.6	4.4	A.C. power ground
4.2	4.2	Aware of and utilizes information sources especially specification sheets
4.2	4.0	A.C. power instruments (grounding)
4.0	4.2	Ground loop
4.0	4.1	Effects of input and output impedance on measurement shunt series, impedance matching
4.2	3.8	Overloading
4.0	3.8	Identify sources of measurement error
3.9	4.1	Precision
4.1	3.6	Voltage transients
3.7	3.9	Shielding (electric field)
3.7	3.7	Digital vs. analogue readout (accuracy)
3.6	3.5	Shielding (magnetic field)
3.5	3.4	Significant digits
3.5	3.4	Battery powered instruments--grounding
3.6	3.0	Cross talk
2.7	2.6	Differential input
2.3	2.5	Guarding

Table 3B

Concepts in Electronic Instrumentation Having a Standard Deviation>1.2 on Level of Importance Responses

Technician Mean	Employer/ Supervisor Mean	Concept
3.7	4.1	Multiple ground
3.7	3.9	Per cent error
3.5	4.0	Fabrication (coax. connectors)
3.2	3.9	Contact potential
3.3	3.6	Connector impedance match (coax.)
3.5	3.4	High current ground
3.3	3.3	Instrument noise
3.2	3.3	Prepare graphs, charts

are necessary for proper integration of the data

4. Competency 4--Utilizes safety and insulating techniques when making measurements with the instrument
5. Competency 5--Utilizes proper calibration technique in maintaining instrument

B. Concepts

1. Digital versus analogue readout
2. Per cent error
3. Precision
4. Significant digits
5. Identifying sources of measurement error

II. Weeks 4-6

A. Instrument--oscilloscope with triggered sweep

1. Competency 1--Utilizes less than the total capacity of the instrument
2. Competency 2--Utilizes all instrument functions in standard applications
3. Competency 3--Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper integration of the data
4. Competency 4--Utilizes safety and insulating techniques when making measurements with the instrument
5. Competency 5--Utilizes proper calibration technique in maintaining instrument

B. Concepts

1. Safety grounding
2. A.C. power grounding
3. Battery power instruments
4. A.C. power instruments
5. Ground loop
6. Multiple ground
7. High current ground

III. Weeks 7-8

A. Instrument--regulated D.C. power supplies

1. Competency 1--Utilizes less than the total capacity of the instrument
2. Competency 2--Utilizes all instrument functions in standard applications
3. Competency 3--Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper integration of the data
4. Competency 4--Utilizes safety and insulating techniques when making measurements with the instrument
5. Competency 5--Utilizes proper calibration technique in maintaining instrument (as time permits)

IV. Week 9

A. Instruments--recorders and printers

1. Competency 1--Utilizes less than the total capacity of the instrument
2. Competency 2--Utilizes all instrument functions in standard applications
3. Competency 3--Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper integration of the data

4. Competency 4--Utilizies safety and insulating techniques when making measurements with the instrument (as time permits)
5. Competency 5--Utilizes proper calibration technique in maintaining instrument

In determining the above schedule, the following specific factors were considered:

Week 1-3. When choosing between the use of digital or analogue volt ohmeters, the concepts of (1) digital versus analogue readout, (2) per cent error, (3) precision, (4) significant digits, and (5) identifying sources of measurement error are essential to the decision making process. Therefore the digital and analogue volt ohmeters would be presented concurrently to provide a meaningful framework.

Objectives pertaining to the digital and analogue volt ohmeter would include learning experiences directed toward Competency Levels 1-5. The mean rating, essential/important, for these competencies (as applied to the volt ohmeters) were the basis of this course decision.

Weeks 4-6. The next instrument to be presented in the course would be the oscilloscope with triggered sweep. In the process of covering the concepts and competencies of an oscilloscope with triggered sweep, all of the competencies necessary to application of the oscilloscope without triggered sweep will be developed. The oscilloscope

without triggered sweep will not be covered as a separate topic in the course.

One of the primary concerns in the use of an oscilloscope, when making measurements in a circuit (especially in A.C. power systems), is the consideration of ground connections. Because the use of the oscilloscope provides an excellent motivational factor, concepts of (1) safety grounding, (2) A.C. power grounding, (3) battery power instruments, (4) A.C. power instruments, (5) ground loop, (6) multiple ground, and (7) high current ground would be discussed in conjunction with the oscilloscope. As with the volt ohmeters, objectives pertaining to the oscilloscope would provide learning experiences directed toward Competency Levels 1-5.

Weeks 7 and 8. Regulated D.C. power supplies would be the topic for weeks seven and eight. Both current and voltage limits would be incorporated in the discussion to assure the development of Competency Levels 1-3. Utilization of safety and insulating techniques would be discussed to fulfill the requirements of Competency 4. Learning experiences directed toward Competency 5 would be included as time permits due to its comparative lower Level of Importance.

Week 9. Competency Levels 1, 3 and 5 would be the primary emphasis for recorders and printers--the last instrument to be covered in this section. At this point in the course progression, Competency 4 should not

require significant attention. The comparatively low Level of Importance placed on Competency 2 (utilizes all instrument functions) indicates that the student does not need to be competent in all instrument functions. The instructor will carry out further investigation or use his professional judgement to determine the instrument functions that should be emphasized under Competency 1.

A brief introduction to the use of instruction manuals (Competency 10) will be covered on all five instruments during the first nine week period. This objective (use of instruction manuals) as well as Competency 6 (utilizes instrument in troubleshooting) would be met primarily during the second seven weeks of the semester. With the help of the instructor, the student will use the instruction manual to demonstrate appropriate functions on the remaining ten instruments listed in Table 2. This would meet the requirement for proficiency in Competency 10. Required competency levels with each of the remaining instruments are determined by the dictates of time and questionnaire results.

Shielding (electric and magnetic) cross talk, voltage transients, and overloading are concepts that are given priority during the second seven weeks of this semester. Being aware of and utilizing information sources especially specification sheets is a concept that is integral to the use and application of instruction manuals,

and therefore is not included as a separate item in the course content.

Using this overview, a specific course format was developed for the second seven week segment:

I. Week 10
   A. Instrument--oscilloscope with greater than 20 MegHz. frequency
      1. Competency 1--Utilizes less than the total capacity of the instrument
      2. Competency 2--Utilizes all instrument functions in standard applications
      3. Competency 3--Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper integration of the data
      4. Competency 4--Utilizes safety and insulating techniques when making measurements with the instrument
   B. Concepts
      1. Electric field shielding
      2. Magnetic field shielding

II. Week 11
   A. Instrument--pulse generators
      1. Competency 1--Utilizes less than the total capacity of the instrument

2. Competency 2--Utilizes all instrument functions in standard applications (as time permits)
3. Competency 3--Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper integration of the data
4. Competency 4--Utilizes safety and insulating techniques when making measurements with the instrument (as time permits)
5. Competency 5--Utilizes proper calibration technique in maintaining instrument (as time permits)

B. Concepts
1. Electric field shielding (continued)
2. Magnetic field shielding (continued)

III. Week 12

A. Instruments--microprocessor test instruments--logic analyzer, logic probe and logic clip
1. Competency 1--Utilizes less than the total capacity of the instrument
2. Competency 3--Utilizes instruments in applications where understanding of the limitations and accuracy of the instrument are necessary for proper integration of the data

3. Competency 6--Utilizes instrument in troubleshooting

B. Concepts

1. Cross talk
2. Electric field shielding (continued)
3. Magnetic field shielding (continued)

IV. Week 13

A. Instruments--signal generators and function generators

1. Competency 1--Utilizes less than the total capacity of the instrument
2. Competency 3--Utilizes instruments in applications where understanding of the limitations and accuracy of the instrument are necessary for proper integration of the data
3. Competency 6--Utilizes instrument in troubleshooting

V. Weeks 14 and 15

A. Instruments--bridge measurements, electrical and electronic standards, D.B. meter and watt meter

1. Competency 1--Utilizes less than the total capacity of the instrument (as time permits)
2. Competency 3--Utilizes instruments in applications where understanding of the limitations and accuracy of the instrument are necessary for proper integration of the

data (as time permits)

3. Competency 6--Utilizes instrument in troubleshooting (as time permits)

VI. Week 16

A. Instruments--decade counters, spectrum analyzers and frequency counters (if time permits)

1. Competency 1--Utilizes less than the total capacity of the instrument

2. Competency 3--Utilizes instruments in applications where understanding of the instrument are necessary for proper integration of the data

B. Concepts

1. Differential amplifier (if time permits)

2. Guarding (if time permits)

In determining the above schedule, the following specific factors were considered:

Week 10. The oscilloscope with greater than 20 MegHz. frequency response and shielding concepts are entered together in the course schedule due to the complementary nature of the instrument and the concepts. The decision to place these items at this point in the schedule was based on four factors: (1) ranking on instrument hierarchy, (2) the first student presentation, (3) prior student exposure to oscilloscopes, and (4) complexity of concurrent course materials (shielding). The student presentation would be

directed toward Competency Levels 1-4 relating to the oscilloscope. As can be noted on the data presentation sheets, these competencies were ranked essential/important.

Week 11. Pulse generators were chosen for this segment of the course to expose the student to pulse characteristics prior to discussion of microprocessor test instruments. The student presentation would be directed to Competency Levels 1 and 3. Competency Levels 2, 4 and 5 would be addressed as time availability dictates. Magnetic and electrostatic shielding concepts would be continued.

Week 12. Although microprocessors are just beginning to achieve a firm foothold in the electronics industry, their future importance is clearly established by the data relating to microprocessor test instruments. Microprocessor test instruments--logic analyzer, logic probe, and logic clip--are presented at this point in the course because of their ranking in the instruments hierarchy. The student presenting these test instruments will direct his presentation to Competency Levels 1, 3 and 6 as clearly dictated by the essential/important ranking of the data. The concepts of shielding are directly linked to the elimination of cross talk in equipment; therefore discussion dealing with cross talk (magnetic and electrostatic shielding concepts) would continue.

Week 13. Due to the similarities in the two instruments, signal generators and function generators were chosen to be presented concurrently in this portion of the course. Since these instruments are used for signal injection in troubleshooting procedures, this is a natural entry for troubleshooting techniques. The student presentation will be directed toward competencies 1, 3 and 6.

Weeks 14 and 15. The four instruments designated for Weeks 14 and 15 including bridge measurements, electrical and electronic standards, D.B. meter, and watt meter have reasonable uniform competency requirements and should be introduced as equipment, time and professional judgement dictates. It should be noted that there were some respondents who interpreted D.B. meter as a sound level instrument and others who responded with vacuum tube voltmeters in mind. Both should be considered during this portion of the course or further study should be carried out to determine the proper emphasis.

Week 16. The final week of the course would include decade counters and, if equipment and time permits, some discussion of spectrum analyzers. (Frequency counters might be included because decade counters are intrinsic to this group of instruments.) If time permits the instructor should consider discussing the concepts of the differential amplifier and guarding unless covered in other portions of the curriculum

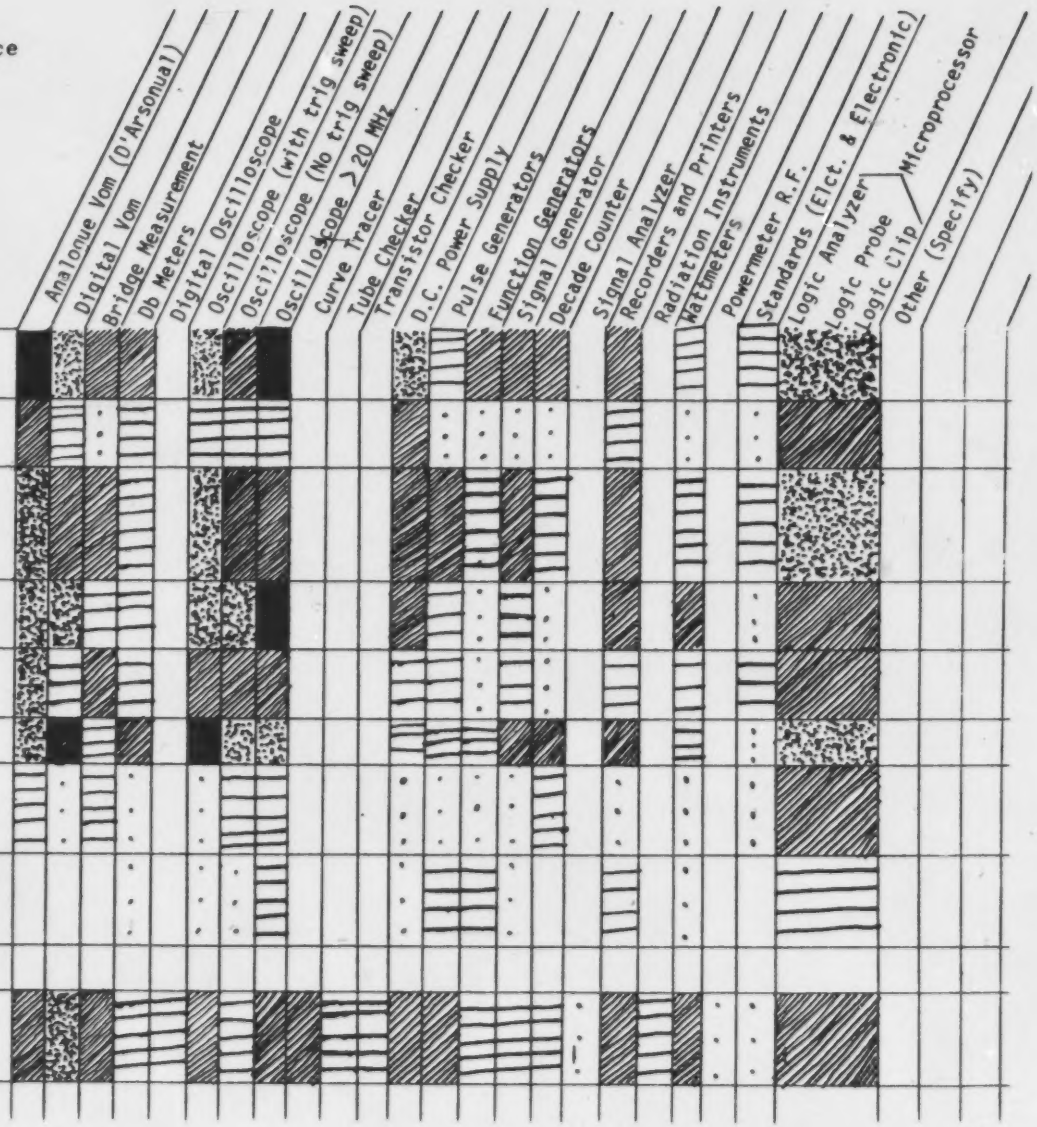
Table 4 Employer/Supervisors--Level of Importance Data with Coded Mean Scores

KEY

- Mean ≥ 4.5
- Mean ≥ 4.0 (< 4.5)
- Mean ≥ 3.5 (< 4.0)
- Mean ≥ 3.0 (< 3.5)
- Mean ≥ 2.5 (< 3.0)
- Mean < 2.5

Level of Importance Data

1. No Importance
2. Slightly Important
3. Average Importance
4. Very Important
5. Essential



1. Utilizes less than the total capacity of the instrument.
2. Utilizes all instrument functions in standard applications.
3. Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper interpretation of the data.
4. Utilizes safety and insulating techniques when making measurements with the instrument.
5. Utilizes proper calibration technique in maintaining instrument.
6. Utilizes instrument in troubleshooting.
7. Utilizes instrument in applications where a knowledge of theory of operation of the instrument is required.
8. Utilizes instrument in applications requiring interface design between the instrument and the measured system.
9. Interfaces transducers with the instrument.
10. Given an unfamiliar instrument and the instruction manual, is able to apply the instrument [redacted].
11. Is able to repair faulty instrument.

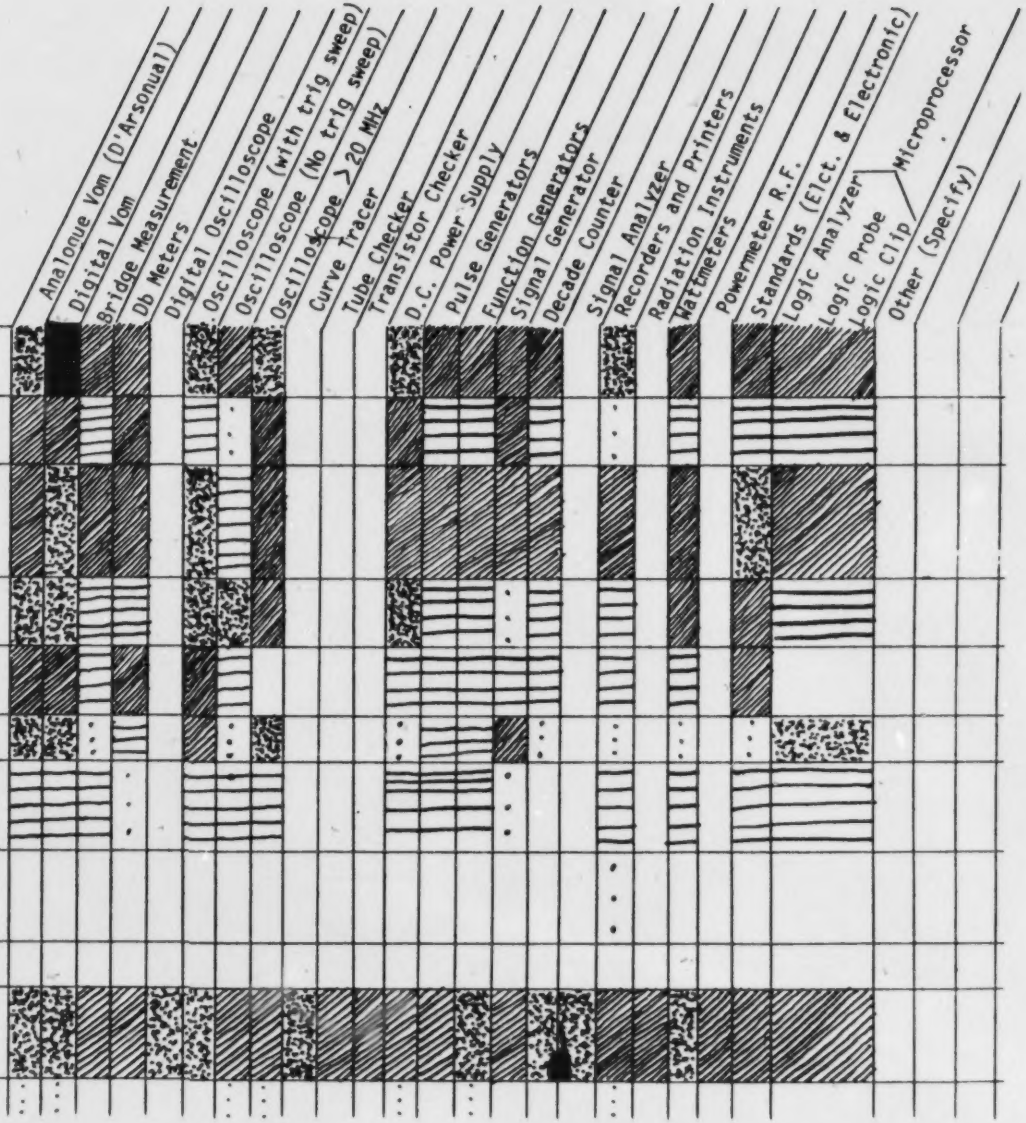
Table 5 Technicians--Level of Importance Data with Coded Mean Scores

KEY

- Mean ≥ 4.5
- Mean ≥ 4.0 (< 4.5)
- Mean ≥ 3.5 (< 4.0)
- Mean ≥ 3.0 (< 3.5)
- Mean ≥ 2.5 (< 3.0)
- Mean < 2.5

Level of Importance Data

1. No Importance
2. Slightly Important
3. Average Importance
4. Very Important
5. Essential



1.	Utilizes less than the total capacity of the instrument.
2.	Utilizes all instrument functions in standard applications.
3.	Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper interpretation of the data.
4.	Utilizes safety and insulating techniques when making measurements with the instrument.
5.	Utilizes proper calibration technique in maintaining instrument.
6.	Utilizes instrument in troubleshooting.
7.	Utilizes instrument in applications where a knowledge of theory of operation of the instrument is required.
8.	Utilizes instrument in applications requiring interface design between the instrument and the measured system.
9.	Interfaces transducers with the instrument.
10.	Given an unfamiliar instrument and the instruction manual, is able to apply the instrument [redacted]
11.	Is able to repair faulty instrument.

Table 6 Employer/Supervisors--Frequency of Use Data with Coded Mean Scores

Frequency Data	KEY
1. No Use	Mean ≥ 4.5
2. Yearly	Mean ≥ 4.0 (< 4.5)
3. Monthly	Mean ≥ 3.5 (< 4.0)
4. Weekly	Mean ≥ 2.5 (< 3.0)
5. Daily	Mean < 2.5

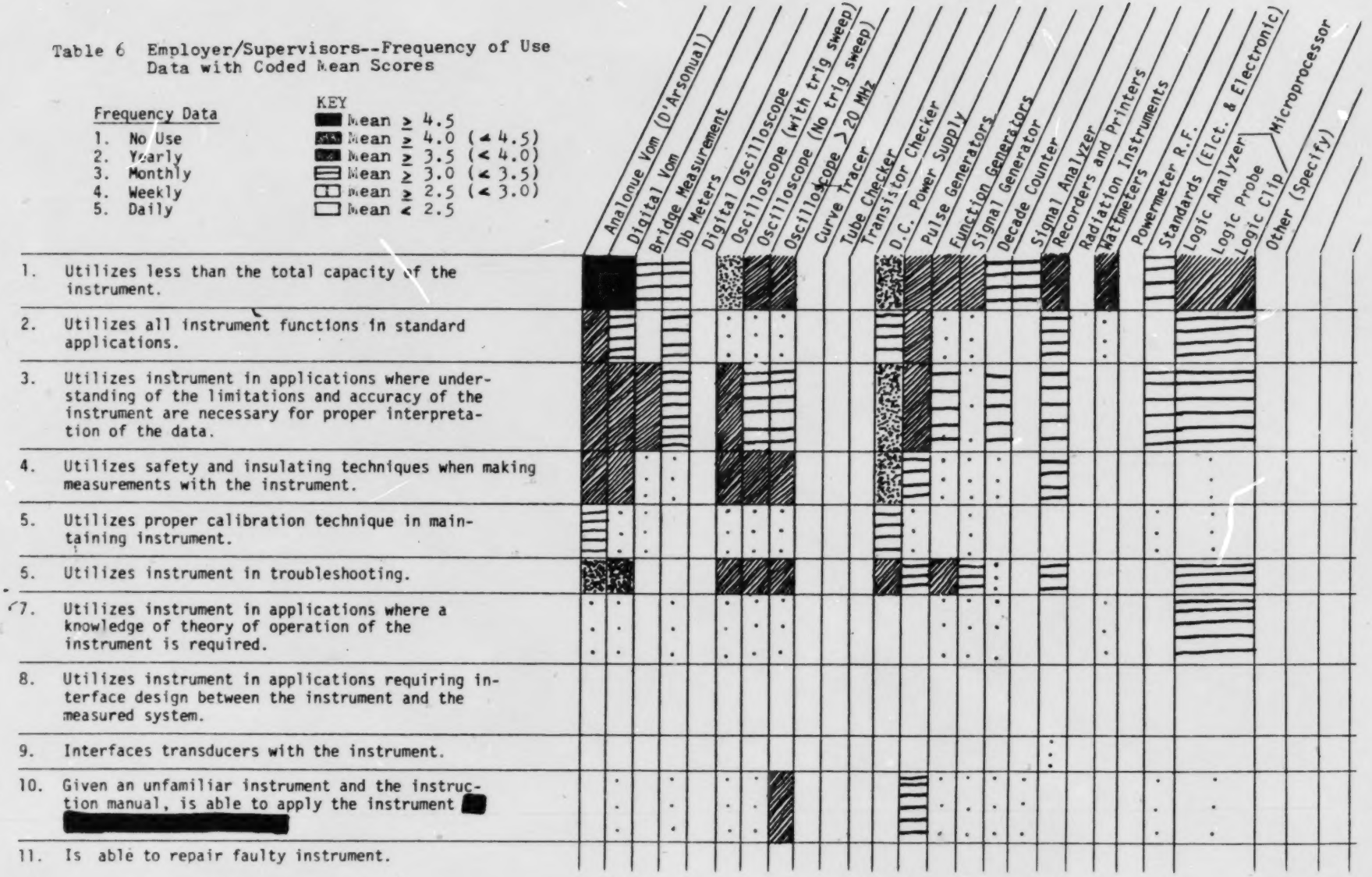
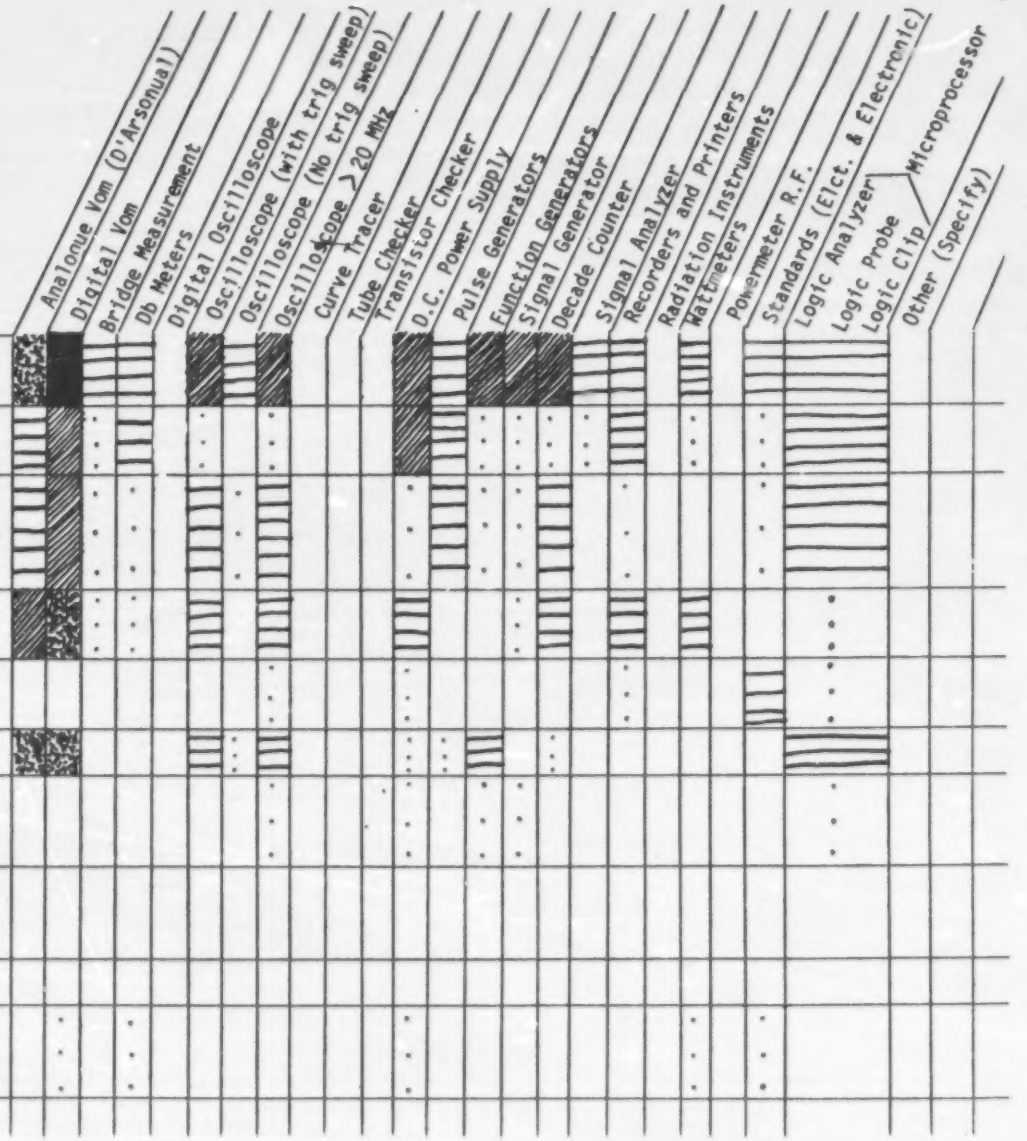

Analogue Vom (O'Arsonual)
Digital Vom
Bridge Measurement
Db Meters
Digital Oscilloscope
Oscilloscope (with trig sweep)
Oscilloscope (No trig sweep)
Oscilloscope ≥ 20 MHz
Curve Tracer
Tube Checker
Transistor Checker
D.C. Power Supply
Pulse Generators
Function Generators
Signal Generators
Decade Counter
Signal Analyzer
Recorders and Printers
Radiation Instruments
Wattmeters
Powermeter R.F.
Standards (Elct. & Electronic)
Logic Analyzer
Logic Probe
Logic Clip
Microprocessor
Other (Specify)
1. Utilizes less than the total capacity of the instrument.
2. Utilizes all instrument functions in standard applications.
3. Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper interpretation of the data.
4. Utilizes safety and insulating techniques when making measurements with the instrument.
5. Utilizes proper calibration technique in maintaining instrument.
6. Utilizes instrument in troubleshooting.
7. Utilizes instrument in applications where a knowledge of theory of operation of the instrument is required.
8. Utilizes instrument in applications requiring interface design between the instrument and the measured system.
9. Interfaces transducers with the instrument.
10. Given an unfamiliar instrument and the instruction manual, is able to apply the instrument [redacted]
11. Is able to repair faulty instrument.

Table 7 Technicians--Frequency of Use Data with Coded Mean Scores

Frequency Data	KEY
1. No Use	Mean ≥ 4.5
2. Yearly	Mean ≥ 4.0 (< 4.5)
3. Monthly	Mean ≥ 3.5 (< 4.0)
4. Weekly	Mean ≥ 3.0 (< 3.5)
5. Daily	Mean ≥ 2.5 (< 3.0)
	Mean < 2.5



1.	Utilizes less than the total capacity of the instrument.
2.	Utilizes all instrument functions in standard applications.
3.	Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper interpretation of the data.
4.	Utilizes safety and insulating techniques when making measurements with the instrument.
5.	Utilizes proper calibration technique in maintaining instrument.
6.	Utilizes instrument in troubleshooting.
7.	Utilizes instrument in applications where a knowledge of theory of operation of the instrument is required.
8.	Utilizes instrument in applications requiring interface design between the instrument and the measured system.
9.	Interfaces transducers with the instrument.
10.	Given an unfamiliar instrument and the instruction manual, is able to apply the instrument [redacted]
11.	Is able to repair faulty instrument.

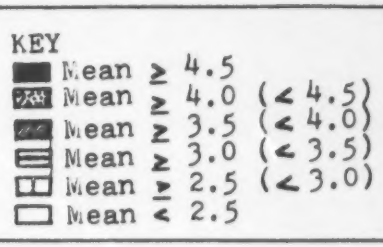
Table 8

Concepts General to the Use of All Measurement Instruments Necessary in Developing Competencies In Electrical Instrumentation
Employer/Supervisors

KEY
- Mean ≥ 4.5
- Mean ≥ 4.0 (< 4.5)
- Mean ≥ 3.5 (< 4.0)
- Mean ≥ 3.0 (< 3.5)
- Mean ≥ 2.5 (< 3.0)
- Mean < 2.5

		Importance	Frequency
I.	Effects of input and output imedance on measurement		
	A. Shunt, series, Impedance matching.		
II.	Noise		
	A. Shielding		
	1. Electric Field		
	2. Magnetic Field		
	B. Common mode interference		
	1. Differential input		
	2. Guarding		
	C. Cross talk		
	D. Contact potential		
	E. Instrument interconnections		
	1. Coaxial Cables		
	a. Connecters terminated properly (fabrication)		
	b. Connecters terminated properly Impedance match or mismatch		
	F. Instrument noise		
III.	Grounding		
	A. Safety grounding		
	B. A.C. power grounds		
	C. Battery powered instruments		
	D. A.C. power instruments		
	E. Ground loop		
	F. Multiple ground		
	G. High current ground		
IV.	Overloading		
V.	Voltage transients		
VI.	Accuracy		
	A. Digital vs. analogue readout		
	B. Precision		
	C. % error		
	D. Significant digits		
	E. Identifying sources of measurement error		
VII.	Aware of and utilizes information sources especially specification sheets.		
VIII.	Prepare graphs, charts and appropriate dialogue relating to results of use of an instrument.		

Table 9
Concepts General to the Use of All Measurement Instruments
Necessary in Developing Competencies
In Electrical Instrumentation
Technicians



I.	Effects of input and output imedance on measurement	
	A. Shunt, series, Impedance matching.	
II.	Noise	
	A. Shielding	
	1. Electric Field	
	2. Magnetic Field	
	B. Common mode interference	
	1. Differential input	
	2. Guarding	
	C. Cross talk	
	D. Contact potential	
	E. Instrument interconnections	
	1. Coaxial Cables	
	a. Connecters terminated properly (fabrication)	
	b. Connecters terminated properly Impedance match or mismatch	
	F. Instrument noise	
III.	Grounding	
	A. Safety grounding	
	B. A.C. power grounds	
	C. Battery powered instruments	
	D. A.C. power instruments	
	E. Ground loop	
	F. Multiple ground	
	G. High current ground	
IV.	Overloading	
V.	Voltage transients	
VI.	Accuracy	
	A. Digital vs. analogue readout	
	B. Precision	
	C. % error	
	D. Significant digits	
	E. Identifying sources of measurement error	
VII.	Aware of and utilizes information sources especially specification sheets.	
VIII.	Prepare graphs, charts and appropriate dialogue relating to results of use of an instrument.	

Week 17. Review

Week 18. Exams

In determining the schedule for the second segment of the course, the following specific factors were taken into consideration. Competency 10 was found to have an essential/important rating by both employer/supervisors and technicians. By having the student utilize equipment instruction manuals to develop a presentation on use of an instrument, the advisory committee felt that proficiency at Competency 10 would be achieved.

Data results indicate that each instrument has its own individual competency level requirements. This required that each presentation have an individual format as prioritized for that specific instrument. The sequence of presentations would occur as specified in the above course schedule.

Required Equipment

The course schedule clearly establishes equipment requirements but specific manufacturers or equipment types are not addressed in this study. Widening the spectrum of equipment manufacturers and equipment models exposed to the student would provide a broad base of reference for the future technician. Fiscal restraints will be a key factor in determining the variety of models made available for student learning. At least one sample of each of the sixteen instruments would be essential to a minimally

effective program. Required equipment would include:

1. Digital volt/ohm meter
2. Analogue volt/ohm meter
3. Oscilloscope with triggered sweep
4. Regulated D.C. power supply
5. Recorder and printer
6. Oscilloscope 20 MegHz. frequency response
7. Pulse generator
8. Logic analyzer, logic probe, and logic clip
9. Bridge
10. Electrical standard (minimum of one sample)
11. D.B. meter
12. Watt meter
13. Decade counter/spectrum analyzer
14. Frequency counter
15. Signal generator
16. Function generator

Summary

The data was analyzed to provide the numerical results of the survey instrument and to develop a proposed instrument course and equipment list.

The first section of this chapter (establishment of criterion-related validity) compared the results of this study with a similar study done by Hagan. While most parts of these studies could not be related and there were significant differences in sampled population, a comparison of four instruments, cited in both surveys, revealed that the two studies placed the four instruments in an identical hierarchy.

In the data analysis, the investigator was able to immediately discard eight instruments from further consideration for an instruments course. Tables ranking the remaining sixteen instruments were prepared and concepts necessary for their proper utilization were identified.

Three competencies were deleted from the twelve instrument competencies. The remaining nine competencies could not be organized into a table as their importance was dependent upon the individual instrument.

The third section of the chapter demonstrated that the data could be used in developing general course objectives, but this was not pursued to the level of specific classroom objectives. An eighteen week instruments

course was planned. The five most important instruments, the concepts relating to grounding, and the concepts relating to accuracy are presented in the first nine weeks. Student reports on the remaining ten instruments would highlight the final seven weeks of the course. Each student, under the supervision of the instructor, would be required to use instruction manuals (Competency #10) to demonstrate appropriate functions on one of these ten instruments. The concepts of shielding, cross talk, voltage transients, and overloading would also be presented during this last seven weeks. An instrument equipment list was also prepared to guide the WVTAE school in equipment budgeting and purchase.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

In order to prepare an up-to-date instruments course for an associate degree electronics curriculum, the investigator surveyed 43 respondents from 24 Wisconsin and Minnesota-based firms to identify job-entry skills expected of the electronics technician. This concluding chapter will address the following three topics: (1) summary of the study, (2) conclusions of the study, and (3) recommendations for further study.

Summary of the Study

This summary reviews the (1) purpose, (2) design, and (3) results of the study.

The Purpose of the Study

Faced with rapidly changing technology, the electronics instructor is concerned that newly graduated electronics technicians would not possess instrumentation skills currently demanded by employers. Thus the purpose of the study was to develop a model that would update the instruments course. Five specific research goals were addressed:

1. To identify instrument and competency priorities which employers and technicians expect of new graduates,

thereby providing a relevant framework for evaluation of existing curriculum priorities.

2. To provide the instructor with information on which to base curriculum changes in preparing for future industry needs.

3. To provide the instructor and administration with information on which to base equipment procurement requests.

4. To provide text publishers with the data necessary to prepare an appropriate instruments text for use in two year associate degree programs.

5. To maintain communication between WVTAE schools and employers.

Design of the Study

A competency analysis (a form of task analysis) was the method chosen for this investigation. Twenty-four employers, chosen by random sample from a study population of 268 employers of WVTAE graduates, participated in the study. Twenty-two employer/supervisors and 21 technicians completed a survey that ranked instruments, competencies, and general electronics concepts.

Results of the Study

The combined opinions of the employer/supervisors and technicians showed that five instruments (digital voltmeter, analogue voltmeter, oscilloscope with triggered sweep, D.C. power supply and recorders/printers) should

form the core of an instruments course. Concepts relating to grounding and accuracy were also considered to be a part of this basic groundwork.

Utilizing the competency analysis, the investigator identified an instruments course that presents this core material during the first nine weeks of the course. The remaining seven weeks are devoted to student presentations of the remaining eleven instruments and other concepts that related to these instruments. An equipment purchase list was prepared to facilitate budget planning.

Conclusions of the Study

Based on the previously goals of the study, the following conclusions were reached:

1. It is possible to identify instrument and competency priorities by using a competency analysis process. When the results of this investigation were validated with a similar study, both surveys placed four instruments in an identical hierarchy. Analysis of the data by mean and standard deviation clearly demonstrated consistent hierarchies of instruments and general concepts among employer/supervisors and technicians.

2. This process of competency analysis provides instructors with information on which to build or revise an instruments course. Utilizing the instruments and competencies hierarchy, the investigator planned an eighteen week instruments course.

3. Equipment procurement requests can be prepared from the competency analysis and resulting instruments course construction. The investigator prepared such a list to demonstrate its usefulness in planning and budgeting.

4. The competency analysis provides an excellent data base from which an author can prepare an instruments text. The resulting instruments and concepts hierarchies combined with designated competency levels would result in a text tailored to the exact needs of instructors, students and future employers.

5. Improved communication with industry was a result of this type of investigation. The investigator found that employer/supervisors and technicians were generally pleased to share their knowledge and opinions with the investigator. Such communication ultimately enhances both the marketability of new graduates and the efficiency of the industry by minimizing on-the-job retraining.

Recommendations for Further Study

During the process of gathering and evaluating the data, the investigator recognized a need for further research into the following areas:

1. During the interviews the investigator had planned on obtaining specific information relevant to "hands-on" experience in the electronics instruments laboratory. As stated earlier this portion of the research

was not completed. The researcher feels that the curriculum could provide a more meaningful learning experience should this type of information be obtained through future studies.

2. A future study should investigate employers' expectations relative to those instruments which received only a priority rating of Competency 1 rather than of Competency 1 and 2. This study could determine exactly which functions were demanded and their priority, further refining articulation between the graduates' training and the employers' expectations. These instruments include: logic analyzer, signal generator, function generator, bridge, electrical standards, D.B. meter, watt meter, decade counter. spectrum analyzer, and frequency counter.

3. It may be important to investigate employers who do not hire associate degree electronics graduates. A study of this type would help the educator in meeting these employers' needs if such action falls within the mandate or financial restrictions of the institution.

4. While many respondents were not familiar with the concept of "common mode interference," the problem probably exists in their firm. A future study should investigate this concept in relation to equipment applications at the job site.

This study has utilized a competency analysis to prioritize the instruments, competencies and related concepts expected of associate degree electronics graduates by

employer/supervisors and technicians. Furthermore, this information has been used to build a model for creating or updating an instruments course for an associate degree electronics curriculum and the organization of such a course has been elaborated. Although this course appears to meet the needs of the associate degree electronics student as perceived by possible employers, the investigator recommends that further research identify more specific applications and functions of instruments.

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Appendix A

Form Letters

MADISON AREA TECHNICAL COLLEGE
211 NORTH CARROLL STREET, MADISON, WISCONSIN 53703

NORMAN P. MITBY
District Director

August 3, 1977

Dear

As Mr. Lehrman's letter indicates, I would appreciate your help in obtaining a realistic overview of the present and projected instrument-related skills pertinent to the occupation of electronics technicians.

I will be contacting you by phone to answer any questions you may have and to plan for an interview with a management/supervisory person and an interview with an electronics technician.

As an instructor in electronics, I will be returning to my teaching position at the beginning of fall semester - therefore I would like to schedule these interviews during August.

Should you wish to contact me, feel free to phone me at (608) 256-0921 or send a note to my home, 1030 Vilas Avenue, Madison, Wisconsin 53715.

The results of this survey will be furnished to you upon your request.

Sincerely yours,

Eugene Salberg

Eugene Salberg

State of Wisconsin \ BOARD OF VOCATIONAL, TECHNICAL & ADULT EDUCATION

EUGENE LEHRMANN
State Director
4802 Sheboygan Avenue 7th Floor
MADISON, WISCONSIN 53702

M E M O R A N D U M

TO: EMPLOYERS OF INSTRUMENTATION AND ELECTRONICS TECHNOLOGY GRADUATES

FROM: Eugene Lehrmann, State Director EL

SUBJECT: EVALUATION OF PROGRAMS

DATE: July 6, 1977

We are pleased that you have employed graduates from one of our vocational-technical schools.

The State Board of Vocational, Technical and Adult Education is supporting Gene Solberg of Madison Area Technical College in our efforts to develop curriculum information for the Instrumentation and Electronics Technology Programs. We believe that as an employer of electronics technicians, you are in the best position to identify the areas of knowledge and competencies that electronics technicians are presently utilizing and will be required to use in the future (two to five years).

Specifically, Mr. Solberg is interested in electronic instruments. He would appreciate your assistance in identifying competencies required of technicians in the application, calibration and maintenance of electronic instruments (oscilloscope, DVOM, etc.).

We would greatly appreciate your assistance along with other Wisconsin-based employers in approving two interviews: 1) an interview with a management/supervisory person (knowledgeable about the job requirements of electronics technicians), and 2) an interview with an electronics technician employed by your firm.

Your assistance will help our VTAE system in providing electronics technicians that best serve the needs of Wisconsin employers.

EL/RJK/pcs

Appendix B

Data Collection Instruments

Interviewee: _____

Firm: _____

Concepts General to the Use of All Measurement Instruments Necessary in Developing Competencies In Electrical Instrumentation

		Importance	Frequency
I.	Effects of input and output impedance on measurement A. Shunt, series, Impedance matching.		
II.	Noise A. Shielding 1. Electric Field 2. Magnetic Field B. Common mode interference 1. Differential input 2. Guarding C. Cross talk D. Contact potential E. Instrument interconnections 1. Coaxial Cables a. Connecters terminated properly (fabrication) b. Connecters terminated properly Impedance match or mismatch F. Instrument noise		
III.	Grounding A. Safety grounding B. A.C. power grounds C. Battery powered instruments D. A.C. power instruments E. Ground loop F. Multiple ground G. High current ground		
IV.	Overloading		
V.	Voltage transients		
VI.	Accuracy A. Digital vs. analogue readout B. Precision C. % error D. Significant digits E. Identifying sources of measurement error		
VII.	Aware of and utilizes information sources especially specification sheets.		
VIII.	Prepare graphs, charts and appropriate dialogue relating to results of use of an instrument.		

Interviewee: _____

Firm: _____

~~Frequency Data~~

1. ~~No Use~~
2. ~~Yearly~~
3. ~~Monthly~~
4. ~~Weekly~~
5. ~~Daily~~

Level of Importance Data

1. No Importance
2. Slightly Important
3. Average Importance
4. Very Important
5. Essential

	Analogue Vom (O'Arsonual)	Digital Vom	Bridge Measurement	Db Meters	Digital Oscilloscope	Oscilloscope (with trig sweep)	Oscilloscope (No trig sweep)	Oscilloscope > 20 MHz	Curve Tracer	Tube Checker	Transistor Checker	D.C. Power Supply	Pulse Generators	Function Generators	Signal Generators	Decade Counter	Signal Analyzer	Recorders and Printers	Radiation Instruments	Wattmeters	Powermeter R.F.	Standards (Elct. & Electronic)	Logic Analyzer	Logic Probe	Logic Clip	Microprocessor	Other (Specify)
1. Utilizes less than the total capacity of the instrument.																											
2. Utilizes all instrument functions in standard applications.																											
3. Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper interpretation of the data.																											
4. Utilizes safety and insulating techniques when making measurements with the instrument.																											
5. Utilizes proper calibration technique in maintaining instrument.																											
5. Utilizes instrument in troubleshooting.																											
7. Utilizes instrument in applications where a knowledge of theory of operation of the instrument is required.																											
8. Utilizes instrument in applications requiring interface design between the instrument and the measured system.																											
9. Interfaces transducers with the instrument.																											
10. Given an unfamiliar instrument and the instruction manual, is able to apply the instrument to its maximum capabilities.																											
11. Is able to repair faulty instrument.																											

Interviewee: _____

Firm: _____

Frequency Data	Level of Importance Data
1. No Use	1. [illegible]
2. Yearly	2. [illegible]
3. Monthly	3. [illegible]
4. Weekly	4. [illegible]
5. Daily	5. [illegible]

	Analogue Vom (D'Arsonual)	Digital Vom	Bridge Measurement	Db Meters	Digital Oscilloscope	Oscilloscope (with trig sweep)	Oscilloscope (No trig sweep)	Oscilloscope > 20 MHz	Curve Tracer	Tube Checker	Transistor Checker	D.C. Power Supply	Pulse Generators	Function Generators	Signal Generators	Decade Counter	Signal Analyzer	Recorders and Printers	Radiation Instruments	Wattmeters	Powermeter R.F.	Standards (Elct. & Electronic)	Logic Analyzer	Logic Probe	Logic Clip	Microprocessor	Other (Specify)
1. Utilizes less than the total capacity of the instrument.																											
2. Utilizes all instrument functions in standard applications.																											
3. Utilizes instrument in applications where understanding of the limitations and accuracy of the instrument are necessary for proper interpretation of the data.																											
4. Utilizes safety and insulating techniques when making measurements with the instrument.																											
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6. Utilizes instrument in troubleshooting.																											
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8. Utilizes instrument in applications requiring interface design between the instrument and the measured system.																											
9. Interfaces transducers with the instrument.																											
10. Given an unfamiliar instrument and the instruction manual, is able to apply the instrument to its maximum capabilities.																											
11. Is able to repair faulty instrument.																											